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ABSTRACT

This booklet reports the results of a recent National Science Foundation study of the impact of mandated testing programs on curriculum and instruction in elementary and secondary mathematics and science education, especially the impact on teachers with large percentages of minority students. The study included three strands: (1) an item-by-item analysis of the most widely-used standardized tests and textbook tests in mathematics and science for grades 4, 8, and selected high school subjects; (2) a nationwide questionnaire survey responded to by 2,229 mathematics and science teachers in grades 4-12; and (3) interviews with 200 teachers and 100 administrators in 6 urban districts in 6 states nationwide. Included is a figure titled "Percent of items testing types and levels of thinking" and two tables titled "Percent of teachers reporting preparation for mandated standardized tests (nationwide survey of 2,229 teachers)" and "Percent of teachers with positive and negative views of mandated testing programs (interviews with 200 mathematics and science teachers in 6 urban districts)." Impact on minority students and other issues are discussed. The last page includes an order form for this and other reports. (MKR)

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The Influence of Testing on Teaching Math and Science in Grades 4-12

Report of a study funded by the National Science Foundation (SPA8954759) and conducted by the Center for the Study of Testing, Evaluation, and Educational Policy, Boston College.

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~~Katherine A. Viator~~

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

About this report

This booklet reports the results of a recent National Science Foundation study of the impact of mandated testing programs on curriculum and instruction in elementary and secondary math and science education, especially the impact on teachers with large percentages of minority students.

The study included three strands —

- an item-by-item analysis of the most widely-used standardized tests and textbook tests in math and science for grades 4, 8, and selected high school subjects;
- a nationwide questionnaire survey responded to by 2229 math and science teachers in grades 4-12;
- interviews with 200 teachers and 100 administrators in six urban districts in six states nationwide.

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The findings and conclusions expressed in this report do not necessarily reflect the position or policies of the National Science Foundation.

Design by Joyce Hempstead.

Betty: Perspectives of an urban teacher

Betty is a fifth grade teacher in an inner city school. Her students are primarily African-American and Hispanic; 85% are eligible for the free or reduced-cost lunch program.

She has been teaching for 8 years; this is her second year at Madison, a K-6 elementary school. She taught 4 years before at a nearby middle school. She was trained at the local state college and has a certificate in elementary education.

In math, Betty's students are subject to state-wide testing with "high stakes." In every school, a certain percentage of students must pass a cutoff score on a standardized test. If only one school fails, the entire district fails state requirements, which may result in takeover of the district by the state. The district has been borderline in passing for several years.

Kay, the interviewer, asked Betty whether she uses a curriculum guide for math:

> *I'm glued to [the curriculum guide] and to children passing the [state-required standardized test]. In the past few years I have been using the curriculum guide to identify objectives in order to teach to the test. The teaching objectives are strictly related to the test. I'm not teaching the items — the test is secure — but teaching the objectives, which are structured to the test.*
>
> *...But teaching to the test leaves little time to bring in things — connect things. I can't branch out in the way I would like — I am working on a strict time-table to cover all of the objectives.*
>
> *Kay: What would you do differently if you had more time?*
>
> *Betty: Abolish the time-table, which is related to taking creativity out of education. The test objectives limit our ability to bring in outside matter. ...Lack of money is another major problem.*
>
> *...If I had more time I would teach at my own pace and at the pace of the students. ...If I didn't have the strict schedule for the test I would stick with an area until the students got it.*

Although she is not deeply familiar with the new approaches to science or math teaching now being recommended by curriculum reformers, her views mirror basic principles of these movements.

Kay: Can you explain more what would you do if you had more time and money?

Betty: More hands-on work, in science especially. Science is theory — it is all well and good to teach this but students need to see it work, they need the model. I would also bring in outside speakers.

She goes on to say that, while time is a constraint, the district's lack of money and the disadvantages that her students suffer are equally important constraints to doing what she would like. Her students come to her poorly prepared. But she does not see the testing program as helping — with her teaching, or their learning.

When asked for any other concerns or opinions about the state-required standardized test, she replied:

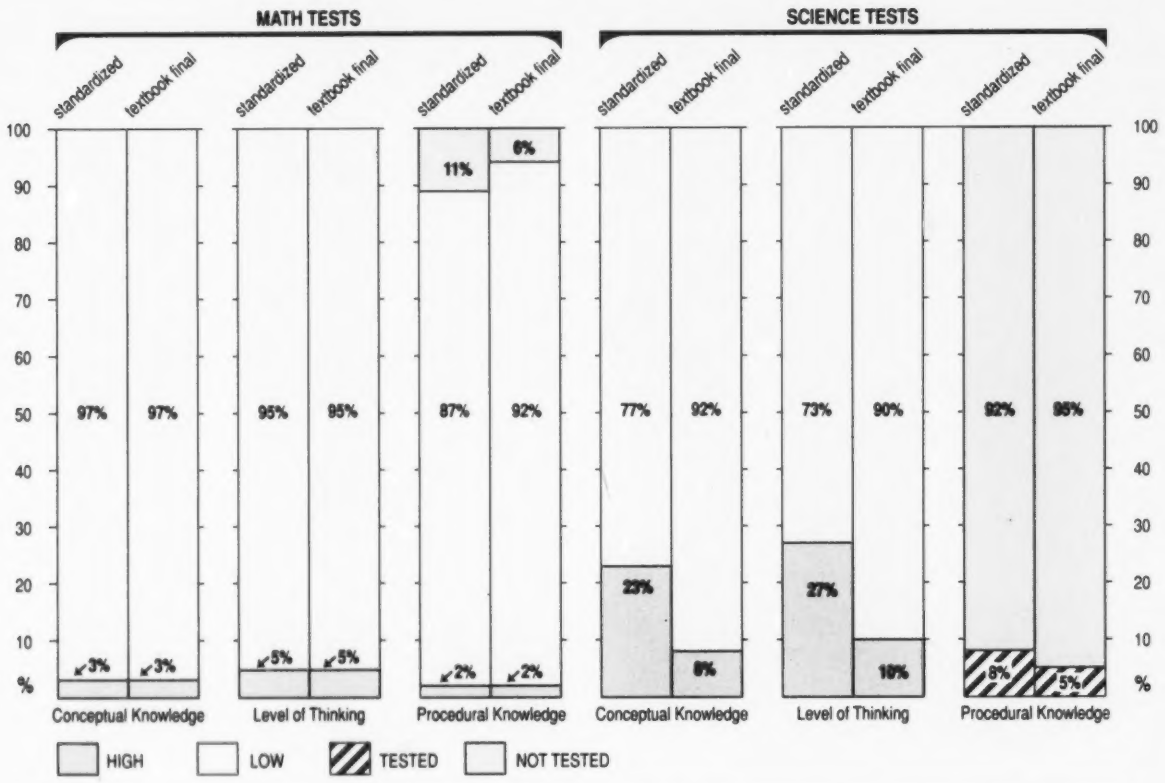
I would like to see standardized tests done away with. The problem with the testing furor is that we place so much emphasis on tests — in the end all the tests place judgment. This intimidates the students. When we use the [standardized test] to group students, children are aware of this. It is used as a measuring stick for success.

In math, Betty follows the textbook for 95% of her teaching. She likes the text because "it has few errors" and it is well aligned with the curriculum objectives and the state test. She uses chapter tests and other tests from the textbook and extra booklets supplied by the publisher. About 90% of the tests and quizzes she gives are publisher-supplied, and 10% are made up by her.

What's on math and science tests used nationwide?

Betty's state test is like standardized tests used nationwide. It is one of six standardized tests analyzed in this study. In the six standardized math tests most widely used in the U.S., 97% of the questions tested low-level conceptual knowledge and 95% tested low-level thinking. Science tests were somewhat better but still low on high-level knowledge and thinking (see Figure 1).

Figure 1: Percent of Items Testing Types and Levels of Thinking [1]



[1]The most widely-used standardized tests and textbook series were selected for grades 4, 8, and the most commonly studied high school subjects.

All items were classified on 3 dimensions: conceptual knowledge, level of thinking, and procedural knowledge. For example, of the 1627 standardized math items, 100% measured conceptual knowledge; 89% measured procedural knowledge, while 11% did not. Of the 1627 items, 95% measured low level thinking, and 5% measured high level thinking.

Definitions of types and levels of thinking were derived from recent curriculum standards and research in math and science. Definitions and examples are detailed in the Executive Summary, Appendix B or C (see list of reports available). For example, high level conceptual knowledge in math or science is evidenced by ability to paraphrase the definition of a concept, generate examples and nonexamples, use models to represent concepts, recognize meanings and various interpretations of concepts, identify critical properties of a given concept, compare/contrast concepts, and apply concepts (as opposed to applying algorithms). High level thinking refers to reasoning and other "higher order thinking skills" (see reports for definition) and low level refers to recall and routine applications. In math and science, conceptual knowledge and level of thinking were categorized as either high or low. The definition of procedural knowledge differs in math and science, referring to use of algorithms in math (low level) or ability to generate, extend or justify procedures (high level), but to the complex of experimental knowledge and procedures in science. Procedural knowledge in science was categorized as present or absent (tested or not tested); in math, it was categorized as high, low or absent.

Percentages shown were computed by pooling test items across grade levels and across all six publishers. See other reports for breakdown by grade level, content areas, and publishers.

Number of items examined:			
	Math:	standardized tests = 1627	textbook final tests = 1423
	Science:	standardized tests = 708	textbook final tests = 1046

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The study also examined tests in the textbook series most widely used nationwide. The study found that textbook tests (including end-of-chapter tests and final course tests) are similar to standardized tests in content, format, and types of thinking. Again, low-level thinking and knowledge predominate. The comparison of types of thinking in standardized tests and final textbook tests in both math and science is shown in Figure 1.

How are test scores used nationwide?

Nationwide, students' scores on mandated standardized tests are used by administrators for student placement or promotion, teacher evaluation, and school or district evaluation. Specific uses affecting students are placement in remediation, special services, advanced classes or other ability tracks, and promotion/retention, or high school graduation. In the nationwide survey, from 17% to 57% of math teachers reported that scores on mandated standardized math tests were "very important" or "extremely important" for student placement, student promotion/graduation, teacher evaluation, and school/district evaluation. Variation depended on type of use and grade level. In science, such reliance on test scores ranged from 13% to 50%.

In interviews we found that, in districts and schools with less emphasis on standardized test scores, and without such severe penalties attached, teachers felt more at liberty to adopt innovative curriculum materials designed to support higher-order thinking, and were doing so.

As for textbook tests, the survey found them typically used every one to three weeks. These test scores often determine a large portion of students' term grades, and grades in turn influence decisions about student promotion and placement.

Impact on minorities

In the nationwide survey, teachers with high percentages of minority students (in a particular class) reported more reliance on standardized tests for the purposes above than did teachers with few minority students. They also felt more pressure: of teachers who had mandated tests in their subject, about 75% of both math and science teachers with high-minority classes reported pressure from their district to improve standardized test scores, in comparison with about 60% of teachers with low-minority classes. High-minority classrooms had more low-income children (as indicated by children receiving Chapter 1 services), and were more often located in urban settings.

In the nationwide survey, teachers of high-minority classrooms reported test-oriented teaching practices more often than teachers of low-minority classrooms (see Table 1). For example, in high-minority classrooms, about 60% of the teachers reported teaching test-taking skills, teaching topics known to be on the test, increasing emphasis on tested topics, and beginning preparation more than a month before the test. These practices were reported significantly less often in low-minority classrooms.

Like Betty, teachers with "high stakes" tests often voiced negative views of test validity, and of the effects of their testing programs on student learning and on motivation of both teachers and students (see Table 2). Among 200 teachers interviewed in our six urban districts, all math teachers and 80% of science teachers had at least one test that was heavily used for one or more of the purposes described on page 4. Sixty percent of math teachers and 63% of science teachers described negative effects of the testing program on curriculum or student learning. They stated, for example, that the mandated testing caused narrowing and fragmenting of the curriculum, limited the nature of thinking, or forced them to rush too much for students to learn well. Of 17% who mentioned positive effects on curriculum or learning, most cited mere "coverage" of curriculum. Two-fifths of math teachers and one-fifth of science teachers noted negative impact on student or teacher motivation. Only about 10% mentioned any positive impact of testing programs on motivation.

Table 1: Percent of teachers reporting preparation for mandated standardized tests[1] (nationwide survey of 2229 teachers)

Minority[2] presence		High-minority class: More than 60% of students are minorities	Low-minority class: Less than 10% of students are minorities
How do you prepare your students[3] for the mandated standardized test you indicated?			
Teach test-taking skills	math	84	55
	science	75	42
Encourage students to work hard on tests	math	61	49
	science	74	50
Use test-motivating materials	math	57	19
	science	64	22
Teach topics known to be on test	math	60	37
	science	60	19
Provide test-specific material	math	38	12
	science	29	6
Provide similar items	math	61	31
	science	34	13
More than 20 hrs of preparation	math	31	9
	science	21	4
Prep. month or more before test	math	74	32
	science	49	39
Use state/district test prep. materials	math	14	7
	science	11	6
Use practice tests	math	32	12
	science	20	10
To what extent[4] does the mandated standardized test influence you and your teaching to...			
Include topics not otherwise taught	math	58	42
	science	71	33
Exclude topics otherwise taught	math	39	20
	science	41	16
Increase emphasis on certain topics	math	71	46
	science	67	38
Decrease emphasis on certain topics	math	49	25
	science	47	26
Alter content of teacher-made tests	math	45	32
	science	53	25
Alter format of teacher-made tests	math	51	38
	science	48	26

[1]Statistically significant differences between high-minority classes and low-minority classes are shaded ($p < .05$). [2]"Minority" is defined according to the categories developed by the U.S. Office of Management and Budget (OMB Directive 15) and commonly used in government statistics. They include African-American, Hispanic, Asian/Pacific Islander, and Native-American/Alaskan. [3]Teachers with more than one class were instructed to select their first Monday class. [4]Extent of influence indicated by these teachers was "some" or "a lot".

Table 2: Percent of teachers with positive and negative views of mandated testing programs[1] (interviews with 200 math and science teachers in 6 urban districts)

Type of view		Negative	Positive
View of impact on curriculum and learning	math	60	16
	science	63	17
View of impact on student or teacher motivation	math	43	11
	science	18	10
View of test validity	math	45	8
	science	73	3

[1]Percentages indicate the percentage of teachers interviewed who made one or more comments on these topics. Comments on these topics were compiled from various interview questions about instruction and assessment rather than from any one specific question.

Issues

The tests commonly taken by students — both standardized tests AND textbook tests — emphasize low-level thinking and knowledge. Since textbook tests and standardized tests are similar, the presence of low-level thinking extends beyond the instructional time spent preparing for state and district mandated standardized tests. State and district tests, and textbook tests, mutually reinforce an emphasis on low-level thinking and knowledge. These tests do not meet current recommendations of science and math curriculum experts nationwide. Their uses and effects are negatively viewed by many teachers who work under the mandate of "high stakes" testing programs.

There is more reliance on mandated test scores in high-minority classrooms than in low-minority classrooms. Teachers of high-minority classes report more test pressure and test-oriented instruction than teachers of low-minority classes. Yet such teachers do not believe that these testing programs benefit curriculum, instruction, or learning.

These results suggest a gap in instructional emphases between high and low-minority classrooms that conflicts with our national concern

for equity in the quality of education. The results also suggest a gap between district/state testing policies and teachers' own ideas about good educational practice. The latter gap conflicts with our national concern to honor local control in general, and teachers' professional judgment in particular. Both of these conflicts need attention as we strive to reform curriculum, assessment, teaching, and schools.

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